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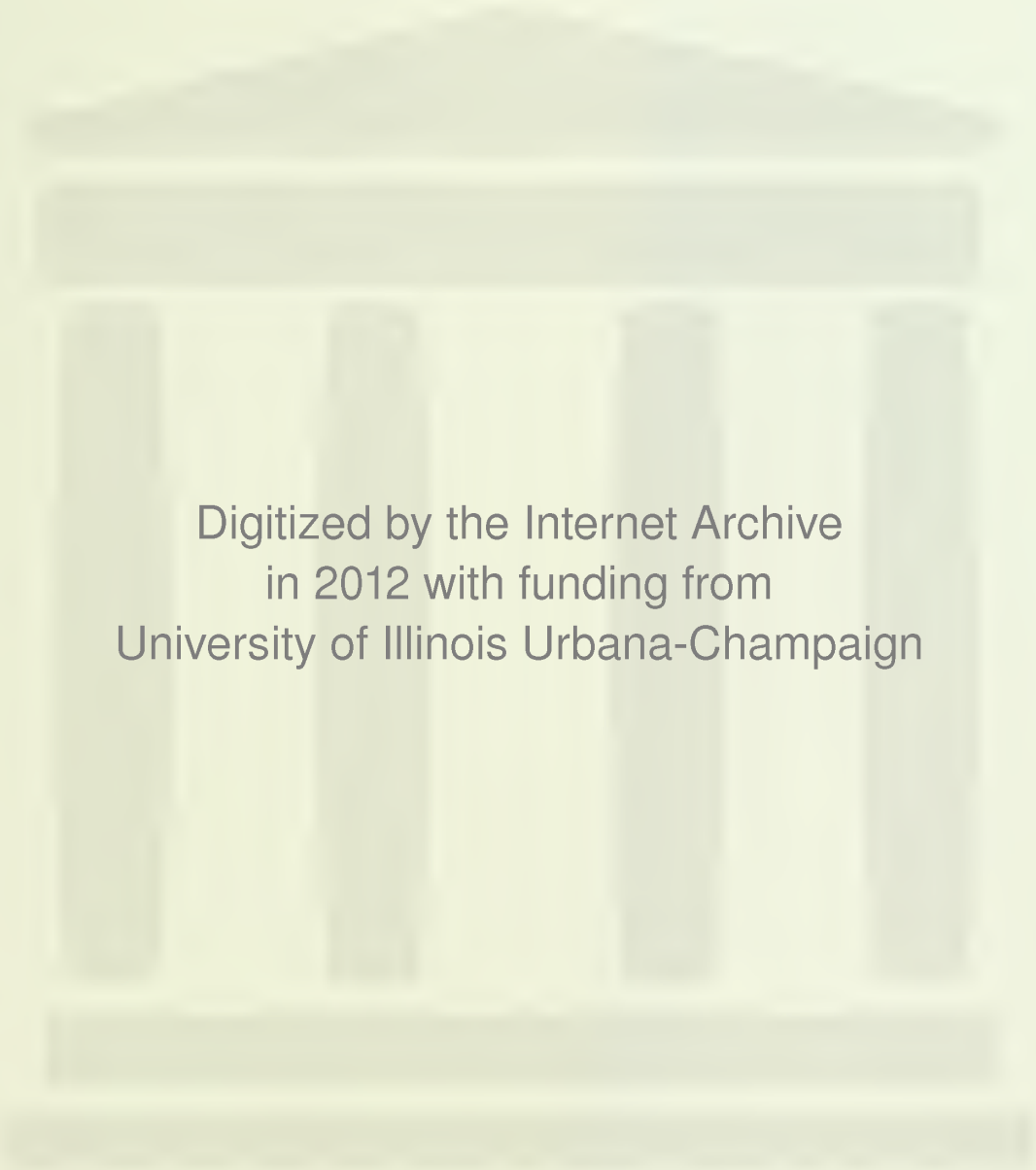

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More on Overdrafts and the Demand for Money

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More on Overdrafts and the Demand for Money

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Abstract

Bar-Ilan (1990) has developed a simple model and a stochastic model of money demand with overdrafting. It is shown here that the simple model is not likely to be important empirically. The stochastic model is shown to be misspecified and unrealistic. Following previous work a truly stochastic model is developed with both interest on money paid and overdrafting allowed. In this model money demand is independent of the level of interest rates depending instead solely on the structure of interest rates. Reasons are given for not including overdraft usage as part of the money supply.

The introduction of overdrafts into standard money demand models is important not only for those many economies where overdrafts currently exist, but also because it seems likely that the U.S. economy is headed toward more formal arrangements and more widespread use of overdrafting privileges. Adding overdrafts to money demand models along with interest payments on deposits whether through NOW accounts for households or through compensating balance arrangements for nonpersonal accounts is clearly of interest in the U.S. context. However, the so-called "stochastic" model developed by Bar-Ilan (1990) is wrongly specified and unrealistic at the same time. In addition, his simple deterministic model, a variation of the standard Allais, Baumol, Tobin (ABT) model may not be very realistic. For the stochastic model, the problems are the all too common mistake of confusing variability with uncertainty of cash positions and the inappropriate use of a continuous time model for a process which is by nature discrete. Both problems stem from a lack of awareness of substantial previous work in the area of overdrafts and the precautionary demand for both reserves in the banking context and money in the cash management context.

The purpose of this paper is to correctly specify the stochastic model and to provide some insight into the question of realism for both models.

I. The Simple Deterministic Model

Bar-Ilan adds both an interest return on money and the possibility of using overdrafts to the standard ABT model. Since this model assumes one income receipt at the beginning of each period and a constant flow of payments (or alternatively, a constant flow of receipts and one

payment at the end of the period) it most suitably represents the typical household or a very small business. Larger economic units are likely to have highly variable receipt and payment flows which are ill represented by this type of model. Given this, it is useful to consider how large per period receipts and payments have to be in order to use overdrafts in order to hold "bonds" at all. That is, how large must g, per period income, be for n, the number of transactions in and out of bonds, to be the minimum of two, and have positive profits? Using Bar-Ilan's notation, with K being the fixed cost per transaction, α the bond rate, r the opportunity cost of holding money, p the opportunity cost of using the overdraft, and having money balances have a maximum amount of M and a minimum amount of μ (< 0) where $-\mu$ is the maximum use of overdrafts, total profit from managing cash will be:

$$\pi = \frac{g}{2}\alpha - \frac{nM^2r}{2g} - \frac{n\mu^2P}{2g} - nK \tag{1}$$

with the constraint that $g = n(M-\mu)$. This corresponds to his cost function and yields the same results for his equations (3) and (4), that

$$\mu = -\frac{r}{p}M$$

$$\text{and } M = \left(\frac{2gKp}{r(P+r)}\right)^{\frac{1}{2}}.$$

For purposes here, we are interested in profits when n = 2. However, it is important to note that profits not only must be positive, but must be greater than a "do nothing" policy of simply earning interest on money

and not buying bonds at all. If i_m is the interest rate on money, this profit is just $\frac{g}{2} i_m$. Since $(g/2)(\alpha - i_m)$ is $(g/2)r$, from equation (1) for bonds to be bought and the overdraft used at all,

$$(2) \qquad \frac{gr}{2} - \frac{M^2 r}{g} - \frac{\mu^2 P}{g} - 2K \geq 0.$$

Given optimal μ and the constraint that $g = 2(M-\mu)$, this results in

$$(3) \qquad g \geq \frac{8K(P+r)}{r(p+2r)}.$$

Column one of Table I shows the minimum monthly income (really take-home pay) necessary to invest and use the overdraft for a fixed transactions cost of one dollar and for various annualized interest rates. A two dollar transactions cost would double the monthly income necessary. Twice a month paychecks (rather than monthly) would double the amount of per period pay necessary and thus quadruple the yearly income necessary. Since take-home pay is likely to be in the one-half to two-thirds range of total income, the minimum take-home pay shown in Table I suggest that only the upper middle class would buy bonds and use their overdrafts for transactions demand purposes even with the transactions cost as low as one dollar.

A comparison of the minimums for the various interest rates is interesting. The first four lines differ only by the overdraft rate rising from .10 to .20 and the result is some, but not much, increase in the minimum necessary. This agrees with Bar-Ilan's finding for the

stochastic case, that the trigger points for M and μ do not vary much as the overdraft rate is increased. A halving of both the cost of holding money and the cost of overdrafts doubles the minimum necessary (line 5 compared with line 3). A change in the market rate with both costs remaining the same leaves the minimum the same (line 7 compared with line 5). These last two results show that it is the structure of interest rates rather than their level which determines money behavior in this model. In particular, discussion of "a rise in interest rates," is too ambiguous. For example, a doubling of all interest rates will widen the cost of both holding money and using overdrafts, and will reduce the minimum necessary and increase the demand for money. But an increase of S percentage points for all rates will leave both the minimum and money demand unaffected. The results may be contrasted with those for the standard ABT case of no interest on money and no overdrafts. In this case the minimum income necessary to buy bonds is \$1200 for all cases of Table I except the last (with α = .06) in which case the minimum is \$1600. Contrasting the results with the ABT case in which interest is paid on money but overdrafts are not allowed, the minimum is \$2400 for the first four cases (for r = .04), and \$4800 for the last three (for r = .02).

Although the size of take-home pay appears to rule out most households as candidates to both buy bonds and use overdrafts, the effect on the demand for money is dramatic if indeed they do. Column two of Table I shows the average money holding as a percentage of monthly take-home pay (g). These are without exception very low percentages when compared with the average money holding of 50 percent

under the alternative "do nothing" behavior of simply holding money. The conclusion would have to be that a viable overdraft arrangement would reduce the household money demand to a small fraction of its previous level.

Other than the relatively large size of take-home pay necessary to buy bonds and use overdrafts for transactions purposes, there are other reasons to question the extent to which such behavior would take place. Column three of Table I shows the maximum g for which optimal n is still two and column four shows the profit per month with K equal to one dollar from investing in bonds and using the overdraft. This profit is, of course the maximum obtainable whenever optimal n is two. Column five shows the difference in profit per month from this behavior compared with the "do nothing" behavior. Clearly these profits are trivial. Unless the bond transactions are done on a totally automatic basis, any reasonable accounting of time and effort included in the transactions costs would swamp out any "profits" possible.

In addition to the relatively large take-home pay necessary and the small gain in profits obtainable, three other practical factors will reduce the use of overdrafts and buying bonds. First is the fact that most households have differential payment rates within a payment period saving up bills at the end of the period to be paid after receiving their income. Thus money holdings will be reduced faster at the beginning of the period and slower at the end. This reduces the amount that can be invested as well as the length of time held, and thus further increases the income necessary to make such behavior profitable. Second is the fact that in many cases minimum deposit balances are

required for interest payments on the deposit to be paid or paid fully. Thus drawing down the deposit balance to even some minimum positive level let alone using an overdraft will reduce profits substantially. Finally it might be noted that a household could simply use its credit card more as an alternative to using an overdraft and get free credit for a month.

Given all these problems it seems highly unlikely that using overdrafts and buying bonds will ever be significantly important behavior for households (or other small economic units). This strongly suggests that overdraft usage if it occurs will occur for credit reasons rather than for part of managing transactions demands. And this in turn suggests that overdraft usage should not be included in the money supply. If it were, we would clearly be confounding credit with money.

II. The So-Called "Stochastic" Model and a True Stochastic Model

The simple model with one receipt and constant payouts (or constant receipts and one payment) is applicable only to small economic units such as households. Larger economic units such as firms and state and local governments typically have highly variable payments and receipts. Analysis of money demand in this context started with Miller and Orr (1966) and has been followed by numerous papers, many of which are cited by Bar-Ilan. Although this type of analysis has certainly been popular, there are three important problems with it which taken together suggest that it is both theoretically wrong and empirically irrelevant. First, and most important, it confuses variability with uncertainty. Highly variable receipts and payments cause no problems in cash management that even a dull-pencilled clerk cannot overcome, if the

variable payments and receipts are known with certainty. In the real world for a large economic unit, relatively little of the variability is truly uncertain. Second, cash management is distinctly discrete depending as it does on cash positions at the end of day. A model such as Bar-Ilan's which uses continuous time so that "there is zero probability that money holding will overshoot the thresholds" (footnote 8, page 1204) trivializes the cash management problem. Third, investment in "bonds" is restricted, but decisions made easier, by minimum overnight investment amounts.

Consider the case of an economic unit large enough to be in the market every day. Its daily payments and receipts will certainly be highly variable. However in the real world, it will know for certain the precise amounts of good funds to be received and paid out for all large transactions. And it will have quite good information on the large number of smaller receipts and payments to effect its balance today. One important job of a cash manager is precisely to have this information. The remaining day-to-day uncertainty has been shown to be relatively small, the errors to be unbiased and not serially correlated, and in fact to be adequately represented by a normal distribution (Sprenkle, 1971). All this is greatly different from the typical empirical work using the Miller-Orr model (see, for example, Orr, 1971), which makes no effort to distinguish variability from uncertainty. Any uncertainty tomorrow or later in the week is simply irrelevant for today's decision as to how much money to hold. (It is of course relevant for the maturity of the assets to buy or sell.) For a large economic unit, then, the transactions demand for money (money held with

certainty as to receipts and payments) should be no more than the minimum overnight trading unit plus petty cash and any balances held in small nonoptimized accounts. The remaining day-to-day uncertainty in receipts and payments gives rise to a precautionary demand for money depending on the size of the uncertainty and the interest rates on money and overdrafts if relevant.

For economic units not large enough to be in the market everyday but still large enough to have highly variable receipts and payments, the cash management world is somewhat more complicated. The uncertainty of receipts and payments relevant for cash management will be over a longer time period than one day and thus larger in comparison with the size of the unit. The transactions demand for money will be slightly more difficult, but no real sharp pencils needed, since the clerk will need to know expected net receipts for each of the next some days. This along with minimal trading unit sizes over several days will determine the extent of investing possible, and with knowledge of current interest rates and transactions costs, whether the investment is profitable.

Given this, the Miller-Orr model seems a dead end, and the extension of it by Bar-Ilan using continuous time even worse. The alternative is to use a discrete time model which considers true uncertainty. Such a model has already been developed and applied to the case of overdrafts, contrary to Bar-Ilan who states that "no explicit derivation of the demand for money with overdrafts has been carried out" (page 1201). The models start with Edgeworth (1888) in the banking context. Banks managing their reserve position are very similar to firms managing their cash position. More modern work on banks start

with Porter (1961) and includes among many, Morrison (1966), Baltensperger (1980), Sprenkle (1987) and Spencer (1989). The model as applied to cash management was first developed in Sprenkle and Miller (1980) and later work includes Cuthbertson (1985), Spencer (1986, 1989), Goodhart (1989) and Zilberfarb (1989). All these models include overdrafts or bank borrowing and Sprenkle and Miller includes interest on money (done, however, incorrectly as will be shown) and overdraft borrowing limits (a suggestion of Bar-Ilan's for future research).

The simple version of the model with no limits on overdraft usage and no interest paid on money is as follows, assuming for simplicity that the economic unit is large enough to be in the market every day. Let x be the forecast error of the end-of-day cash balance, such that $x > 0$ indicates unexpected cash needs. Based on the U.S. data mentioned above, x is assumed to be an independent variable distributed as f(x) with a zero mean. For Table II we will also assume that x is normally distributed. Let A, which is to be optimized, be the planned cash holding. The cost of having money is α, the market rate, and the cost of using the overdraft is p the difference between the overdraft and the market rate. The total cost to this large economic unit will be:

$$TC = \alpha \int_{-\infty}^{A} (A-x)\, f(x)\, dx + p \int_{A}^{\infty} (x-A)\, f(x)\, dx. \tag{4}$$

Minimizing with respect to A,

$$F(A^*) = \frac{P}{P+\alpha} \tag{5}$$

where F(A*) is the cumulative probability that cash needs will equal the optimal cash holding. Since p is unlikely to be greater than α, F(A*) is likely to be less than one-half so that the planned holding of money will be negative. It is this result, which in the banking context suggests planned negative reserve (or excess reserve) holdings, which created problems in the banking literature. This can easily be overcome, however, by the addition of a relatively small fixed cost of deficient reserves (see Sprenkle, 1987). For a large economic unit operating under a full blown overdraft system p will be very small indeed, and interest should be in this direction rather than concentrating as Bar-Ilan does, on the use of overdrafts as p gets large. The effects of small p on A* (as a percentage of the standard deviation of x) are shown in Table I of Sprenkle and Miller (hereafter SM) assuming x is normally distributed.

Adding interest on deposits to the model is easy. The cost of holding money is now r rather than α and

$$F(A^*) = \frac{p}{p+r}. \tag{6}$$

(This result was incorrectly obtained as $F(A^*) = \frac{p+\alpha-r}{p+\alpha}$ in SM.) Clearly F(A*), A*, and actual money holdings will be larger, and substantially larger if r is small as it would be in the U.S. context where close to market interest rates are implicitly paid on compensating balances. Also, as for the simple case in part I money holdings are independent of the level of interest rates depending instead solely on the structure of rates. Any stickiness on either the overdraft or the money rate when

the market rate changes will result in a negative elasticity of money however.

Although all the partials are unambiguously signed, because of nonlinearity it is perhaps more instructive to look at some numerical examples. Following SM, the average observed cash holding will be,

$$L = \int_{-\infty}^{A^*} (A^* - x) f(x)\, dx \tag{7}$$

and the average overdraft usage will be

$$B = \int_{A^*}^{\infty} (x - A^*) f(x)\, dx. \tag{8}$$

For a normal distribution with zero mean,

$$L = A^* F(A^*) + \sigma^2 f(A^*) \tag{9}$$

and

$$B = -A^* [1 - F(A^*)] + \sigma^2 f(A^*). \tag{10}$$

Table II, an extension of Table I in SM shows A*, L, and B as percentages of σ for various levels of p/p+r. As can be seen relatively small changes in the interest structure will result in very large changes both in money demand and overdraft usage. Any stickiness in changes in rates when the market rate changes have large effects. For example, if the market rate is originally 8 percent and p and r 2

percent, if the market rate rises by 10 percent to 8.8 percent and the overdraft rate and rate on money remain constant, p will be 1.2 percent, r will be 2.8 percent, and L will fall from .4σ to .18σ--a fall of 55 percent and an elasticity of -5.5. If the overdraft rate rises by .8 so that p stays at 2 percent, but the rate on money remains constant so that r is again 2.8, F(A*) now is .4166 and, interpolating from the table, L will be about .3σ and the elasticity about -2.5. Due to symmetry, the fact that some overdrafts are still used with very high overdraft rates is simply the other side of the fact that some money will still be held even with very high costs of holding money. Possibly the most interesting aspect of Table II is a comparison of the average money holding compared with a no-overdraft case. With a normal distribution of x it is literally impossible to never run an overdraft, but a firm can lower its probability of being overdrawn to any level desired simply by holding more money. For example, if a firm (and its banks) decide that being overdrawn on average no more than once a year is acceptable, then with about 220 working days per year, the probability should be no more than .0045, and the firm should plan to hold 2.61σ of money. If the probability of being overdrawn should be as low as .001, then the firm should hold 3.08σ of money. For most of the range of p and r in Table II average money holdings will be very small fractions of these non-overdraft money holdings. Thus, the introduction of an overdraft system will have an enormous impact on the corporate demand for money function just as it would for the household sector.

The model can easily be expanded by adding overdraft limits. In fact any number of borrowing tranches at higher interest rates can be

added. If C in standardized units is the maximum that can be borrowed at penalty rate p and additional borrowing can be had at a higher rate p_1, then total cost is

$$TC = r\int_{-\infty}^{A}(A-X)\,f(x)\,dx + p\int_{A}^{C+A}(x-A)\,f(x)\,dx + pC\int_{C+A}^{\infty}f(x)\,dx + p_1\int_{C+A}^{\infty}(x-A-C)\,f(x)\,dx. \tag{11}$$

It is presumed that the size of C is negotiated for some fairly extended time period so that optimization is again with respect to A, the planned cash holding. In this case,

$$F(A^*) = \frac{p}{p+r} + \frac{(p_1-p)}{(p+r)}\left[1-F(C+A^*)\right]. \tag{12}$$

F(A*), A*, and L will be larger than before as would be expected, but the interesting question is the size of the increase. In Table III is shown average money holdings for a range of three levels of p/p+r and for p_1 equal to 2p, 4p and 6p, and for overdraft limits of 1σ, 2σ, and 3σ. For all cases, the loan limit plays a negligible role in money demand if the loan limit is at least 3σ. Since σ is the day-to-day (or at least very short run) standard deviation of cash needs, it will be small compared to the likely magnitude of any overdraft limit. This suggests that overdraft limits will not play a role in cash management unless the firm is borrowing close to its limit for general credit purposes rather than for cash management purposes.

Additional borrowing limits can be added. If c_1 in standardized units can be borrowed at p_1, and c_2 an additional amount at penalty cost p_2 ($> p_1$), then

$$(13) \qquad F(A^*) = \frac{p}{p+r} + \left(\frac{p_1-p}{p+r}\right)\left[1-F(C_1+A^*)\right] + \left(\frac{p_2-p_1}{p+r}\right)\left[1-F(C_1+C_2+A^*)\right].$$

Equation (13) can be expanded by sight to include any number of additional borrowing trenches if relevant or desired. Additional borrowing limits, however, will not seriously affect the results shown in Tables II and Tables III.

III. Conclusions

Both the simple model and the truly stochastic model share several characteristics. Wherever empirically relevant, the addition of overdrafts will greatly lower the demand for money to small fractions of its previous level. If interest is paid on deposits, the demand for money is no longer a function of the overall levels of interest rates, but depends instead solely on the structure of interest rates. However any stickiness of either the rate on deposits or the overdraft rate in effect changes the structure of rates, and will have a large effect on the demand for money. All of this suggests a more complex total demand for money function which will be extremely sensitive to small changes in differential interest rates. Before being too alarmed at the resultant possible instability of money demand functions, the question of possible empirical relevance needs to be raised.

As was shown in Section I, it seems unlikely that overdrafts will ever be used for transactions purposes, and the household demand for money will be largely unaffected. For larger economic units possible instability seems more likely. However banking arrangements in the U.S. suggest that a further institutional change would have to take place before the widespread introduction of overdrafting would affect money demand. Although the use of compensating balance requirements in the U.S. has fallen since the 1970s, casual observation suggests that compensating balances are still large. Since compensating balance requirements are set on the basis of <u>average</u> deposit balance rather than a minimum, compensating balances can and do serve the dual function of providing precautionary balances. It was estimated (Sprenkle, 1971) that for large firms compensating balances were about seven times the amount necessary for precautionary balances, and significantly more for those firms with the best cash forecasts. Even a significant drop in compensating balances, thus would leave enough to meet deposit uncertainty. And any increase in forecasting efficiency would lower the precautionary needs. Therefore, unless compensating balance requirements are ended, the introduction of a broad based overdraft system in the U.S. is not likely to affect the demand for money of large economic units.

The suggestion that overdraft usage be included in the demand for money is misguided at best since whether it is households or firms, most overdraft usage will not be for transactions purposes but rather simply a new or different source of general credit. To include overdrafts one would have to argue that the demand for money should include consumer

credit and credit card usage for households and commercial and industrial bank loans for firms under present arrangements. That introducing overdrafts shifts the demand for money is nothing new, so does the payment of interest on money, so does the array of overnight repurchase agreement possibilities, and so does the use of fees rather than compensating balances to pay for some bank services. In fact, any change in the types of characteristics of short term assets and liabilities will affect the money demand function. Overdrafting in this sense is no different.

As for future research, the actual cash management behavior of large economic units needs updating. Compensating balance arrangements have changed and the last study of cash management and cash forecasting is over 20 years old (Sprenkle 1971). In addition the forecasting ability of somewhat smaller economic units along with their cash management techniques needs serious empirical study. Although obtaining the day-to-day forecast and actual data is difficult, substantial gains in understanding money demand behavior should be forthcoming and make the effort well worthwhile.

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Table I

Household Characteristics and Overdrafts

	Annualized Interest Rates			Minimum Monthly Take-Home Pay (times K)	Average Money Demand as percentage of q	Maximum g for n=2	Monthly profit at maximum g (K=$1)	Difference in Monthly Profit From "Do Nothing" Policy
	α	r	p					
1)	.08	.04	.02	$1440	.028	$2025	4.19	$.81
2)	.08	.04	.04	1600	.063	2160	4.29	.70
3)	.08	.04	.08	1800	.111	2314	4.43	.57
4)	.08	.04	.12	1920	.141	2400	4.50	.50
5)	.08	.02	.02	3200	.063	4320	11.50	.70
6)	.08	.02	.04	3600	.111	4630	12.15	.58
7)	.06	.02	.02	3200	.063	4320	9.89	.70

Table II

A*, L, and B as Percentages of σ for Various r and p

$\frac{p}{p+r}$ [$=F(A^*)$]	A*	L	B
.01	-2.33	--	2.33
.02	-2.05	.01	2.06
.05	-1.64	.02	1.66
.10	-1.28	.05	1.33
.20	-.84	.11	.95
.30	-.52	.18	.70
.40	-.25	.28	.53
.50	0	.40	.40
.60	+.25	.53	.28
.70	+.52	.70	.18
.80	+.84	.95	.11
.90	+1.28	1.33	.05
.95	+1.64	1.66	.02
.98	+2.05	2.06	.01
.99	+2.33	2.33	--

Table III

Effects of Loan Limits on Money Demand

$\frac{p}{p+r}$	Original L	Loan Limit C	New L for p_1 equal to 2p	4p	6p
.20	.11	1σ	.16	.35	.60
		2σ	.12	.17	.22
		3σ	.11	.12	.12
.50	.40	1σ	.51	.80	1.26
		2σ	.41	.44	.47
		3σ	.40	.40	.40
.80	.95	1σ	1.04	1.20	1.61
		2σ	.96	.97	.98
		3σ	.95	.95	.95

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